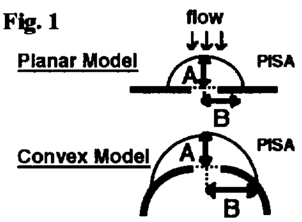
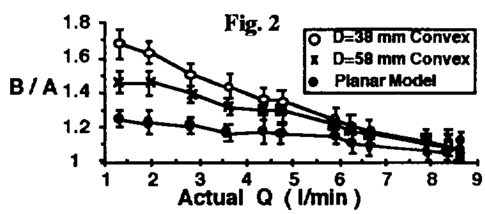
PISA formula for calculating Q across a valve should be different from that for a planar model. We evaluated variations of PISA formula in a planar model and two convex-shaped models. *Methods:* Three circular orifice diameters (Ø = 5.2, 8, 12 mm) on hemispherical balls (diameter, D = 38 and 58 mm) and one planar model were studied in a constant flow system (Fig. 1). The radii (A and B) of PISA were measured in axial and transverse views. Flow velocity and actual Q across orifices were varied from 0.3–7.7 m/s and 0.9–8.6 l/min, respectively. *Results:* 1) B/A ratios were dependent on actual Q and orifice sizes. 2) B/A ratios were significantly larger for convex models than for a planar model at actual Q below 5 l/min ($p < 0.001$) (Fig.2 shows data for orifice Ø = 8 mm at aliasing velocity between 15 and 30 cm/s). 3) In a convex model (D = 38 mm), B/A ratios for orifices Ø = 5.2,8,12 mm at actual Q = 1.5 l/min were 1.35 ± 0.07, 1.62 ± 0.07 and 1.85 ± 0.08, respectively ($p < 0.001$). The D = 58 mm convex model demonstrated similar results. *Conclusion:* The shape of PISA for a convex surface is less hemispherical than for a planar surface. Decreased axial radius is partially compensated for by increased transverse radius. Since precise orifice geometry is often unknown clinically, measurement of both PISA axial and transverse radii is important to minimize under-estimation of regurgitant or stenotic flow.

Fig. 1





1020-5 A Flow Convergence Method to Quantitate Regurgitant Flow with a Flail Mitral Valve Leaflet: Finite Element Modeling and Experimental Studies

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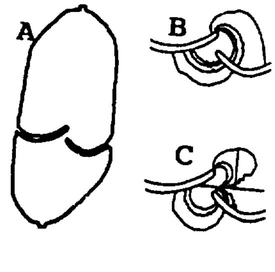
The flow convergence (FC) method has yielded variable results for calculation of regurgitant flow (RF) rates in mitral regurgitation (MR) with a flail mitral valve leaflet (FMVL). Two effects have been postulated as causing errors in FMVL geometry: 1) near the regurgitant orifice (RO) the direction of flow is nearly 90° to the Doppler beam; and 2) left ventricular wall and MVL surface constraints may cause distortion of the assumed hemispherical shape of the FC region. For our finite element modeling study, we used a FMVL model traced from actual echocardiographic images (Fig. A), and simulated continuous flow with RO areas 0.25 and 1.0 cm^2 at RF's of 2, 3, 4, 6, L/min. The isovelocity data (Fig. B) was then adjusted to simulate the angle effects of Doppler sampling from the apex yielding images similar to actual clinical studies (Fig. C). Near the FMVL, as simulated for color Doppler, velocities are underestimated and near the septal leaflet, the isovelocity shells are elongated in a direction towards the scanning origin. The experimental in vitro model had a "smile-shaped" prolapse type orifice 30 mm^2 in cross-sectional area and was studied under pulsatile flow conditions over flow rates for



1.5–20 L/min. With the ultrasound transducer placed at an angle to maximize the extension of the FC alias extension towards the transducer and by using high aliasing velocities so as to mandate correcting for an inlet constraining angle related to leaflet configuration, but not for chamber wall constraint, the correlation for predicting flow was r = 0.97 over flows from 2–12 L/min. The required inlet angle correction could be verified from the relationship of the FC results with the prolapse anatomy and the actual flows but was not required when the flow rate was high enough to be measured outside, or proximal to, the inlet funnel; at which time no correction was necessary. Our studies provide rational and easily implemented approaches useful in adapting the FC method to prolapsed or flail leaflet geometries.

1020-6 Delineation of Three-Dimensional Geometry of Intracardiac Blood Flow Jets and Proximal Flow Convergence Regions in Patients with Flow Abnormalities by Volume-Rendered Three-Dimensional Echocardiography via Transthoracic Imaging

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Volume-rendered three-dimensional echocardiography (3DE) has the capability of not only displaying cardiac structures but also has the potential to depict intracardiac flow jets in a dynamic mode. In this study, we explored the ability of 3DE to provide new information on intracardiac flow disturbances not available from 2D color Doppler. Sequential 2DE images with color Doppler information were acquired using a calibrated rotational scanning method by a transthoracic approach in 34 pts (29 adults and 5 children) with a variety of cardiac disorders. Using a computerized motor coupled to conventional transducers (2 MHz to 5 MHz), 2DE images were collected every 2 degrees over a span of 180 degrees along with ECG and respiratory gating. After digital reformatting, thresholding and adequate segmentation, intracardiac flow jets could be seen in every desired 3DE projection. Flow jet reconstruction was possible in all but 1 pt, yielding a total of 34 jets for review (23 regurgitant jets, 9 stenotic jets and 2 shunts). Central flow jets (n = 24) were the easiest to reconstruct and display in a dynamic 3DE mode, providing an immediate appreciation of their exact shape and spatial extension. Eccentric jets (n = 10) with only partial contact with cavity walls could be reconstructed but required more careful segmentation. However, when the flow jet was in direct contact and alignment with a wall, it was difficult to clearly discriminate the flow data from the tissue signals. When mental 3D appraisal of flow jets (based on combining various 2D color Doppler views) was compared to actual 3DE display of flow jets, there was concordance in all instances of central jets, but when a jet was eccentric, 3DE yielded an easier and frequently different dynamic geometry. Examination of various flow convergence zones (n = 10) by 3DE indicated the absence of a perfect hemispheric geometry in all cases (in contrast to the generally-held assumption of a hemisphere in the use of PISA method). We conclude that 3DE has the potential to provide useful information on flow abnormalities in patients, with important diagnostic and research implications on the study of flow and flow quantitation.

1020-7 Afterload Dependence of Mitral Regurgitant Volume and Regurgitant Orifice Area by Quantitative Doppler

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Quantitation of the severity of mitral regurgitation (MR) is complicated by changes in loading conditions that occur either spontaneously or as a result of therapy. Effective regurgitant orifice area has been proposed as a more fundamental measure of the severity of MR than regurgitant volume. To test the hypothesis that regurgitant orifice area is less dependent on loading conditions than regurgitant volume, we studied the effects of afterload reduction with nitroprusside infusion on regurgitant orifice area and regurgitant volume by quantitative Doppler in 12 patients (age 34 to 77 years) with moderate or severe MR. Etiology of MR was dilated cardiomyopathy in 2, mitral valve prolapse in 7, infective endocarditis in 1, and rheumatic mitral valve disease (without stenosis) in 2. Regurgitant volume was calculated from the stroke volumes (area times velocity-time integral) in the left ventricular outflow tract and mitral annulus. Regurgitant orifice area was calculated as regurgitant volume divided by the velocity-time integral of the MR continuous wave Doppler envelope. MR could not be quantitated in 2 patients with prolapse and markedly eccentric jets due to inadequate alignment of the continuous wave Doppler beam. In the remaining 10 patients, nitroprusside decreased mean regurgitant volume significantly from 138 ± 82 to 116 ± 71 ml ($p = 0.0017$), while mean regurgitant orifice area remained unchanged (1.1 ± 0.7 vs 1.1 ± 0.7 cm^2, $p = 0.64$). Thus in patients with mitral regurgitation, effective regurgitant orifice area is less afterload dependent than